COMPARISON OF FIRE OCCURRENCE IN DESERT AND NONDESERT VEGETATION IN TONTO NATIONAL FOREST, ARIZONA

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Abstract

A 29-yr (1955–1983) record of fires in Tonto National Forest, Arizona was used to compare fire occurrence in desert and nondesert vegetation. Nondesert fires were more numerous, but desert fires were larger, with the result that the mean area burned per square kilometer per year was similar. This similarity in the size of the area burned probably is not representative of prehistoric conditions, but instead may be a result of more effective fire suppression in nondesert vegetation. I speculate that finer fuels and higher rates of spread may allow desert fires to become larger than nondesert fires before being controlled.

Recognition of the ecological linkage among fire frequency, adaptive traits of plants, and the structure of plant communities has improved predictive capabilities, and has contributed to more effective fire management (Bratten 1984). Rogers and Steele (1980) concluded that the frequency of desert fires is impossible to discern in most areas because few desert plants produce annual growth rings that would permit dating of past fires. Because of the discontinuous spacing of desert plants, it has been assumed that fires were infrequent and thus were unimportant ecologically in most of the Sonoran Desert (Humphrey 1974).

Vint and Rogers (in press) used a record of individual fire reports for the period 1955–1983 to estimate fire intervals of 275 and 295 yr for the 391,000 ha desert portion of Tonto National Forest (TNF). The 275-yr value represents the time required for an area equal in size to that of the TNF desert to burn. The 295-yr value represents the time required for all of the TNF desert to burn at least once. The 295-yr value also represents the typical number of years between fires at individual sites in the desert. I use the terms frequency and interval in this manner. The lengths of the intervals estimated by Vint and Rogers (in press) agree with the assumption that desert fires are infrequent, and they agree with the observed low tolerance to burning of most desert plants (Rogers 1985). Vint and Rogers (in press) did not compare the estimated TNF desert intervals with data for the same time period at other sites. In this paper, I assess the accuracy of the intervals by comparing the desert-fire data and results of Vint and Rogers (in press) with data on nondesert-fire occurrence in the remainder of TNF.

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Study Area

The desert portion of TNF contains shrub- and cactus-dominated vegetation representative of the Arizona Upland subdivision of the Sonoran Desert (Brown 1982). It is believed generally that fire occurrence in the Arizona Upland requires the presence of annual plants to provide enough continuous fuel for fire to spread (Lotan et al. 1981, McLaughlin and Bowers 1982). McLaughlin and Bowers (1982) hypothesized that annuals would be most abundant after two consecutive wetter-than-normal winters, because increased seed reserves produced during the first winter would be available for germination during the second. Rogers and Vint (in press) found that fires were more abundant after two wet winters as anticipated by McLaughlin and Bowers (1982).

The nondesert vegetation of TNF includes interior chaparral, conifer woodland, conifer forest, semidesert grassland, and evergreen woodland. Interior chaparral and conifer woodland occupy an area approximately equal to the area of the desert; coniferous forest covers an area approximately one fourth the size of the desert area, and semidesert grassland and evergreen woodland occupy smaller areas. Descriptions of these communities are given in the review by Brown (1982). Fire history for the kinds of nondesert vegetation present in TNF is better known than it is for the desert vegetation (Wright and Bailey 1982). Prehistoric intervals between fires are reported to range from a few years in *Pinus ponderosa* forests (Dieterich 1980) and desert grassland (Humphrey 1958) to 10–30 yr in pinyon-juniper (Wright and Bailey 1982), and less than 100 yr in interior chaparral (Brown 1982).

Fire-history studies in many regions and vegetation types have shown that fire intervals have been abnormally long during the past century (Gruell 1983). Fire frequencies are thought to have declined because of fuel reduction by domestic grazers, inadvertent creation of fire breaks by road construction, and fire prevention and suppression (Humphrey 1958, Gruell 1983). Fires were probably smaller throughout TNF during the 1955–1983 period. Technological advances in fire detection and control, and improved prefire organization probably reduced fire sizes during this period. The use of aircraft to fight fires began in the 1950's (Linkewich 1972); aerial infrared radiation detection systems were introduced in the early 1960's (Hirsch 1962); lightning detection systems in use by the late 1960's have steadily improved (Hawe and Fuquay 1969, Latham 1983); and in 1972, the U.S. Forest Service expanded its fire preparedness and prevention programs (U.S. Forest Service 1977).

Materials and Methods

The 29-yr TNF fire record provides detailed information in regard to fire occurrence for an area of 1,205,000 ha. The record consists

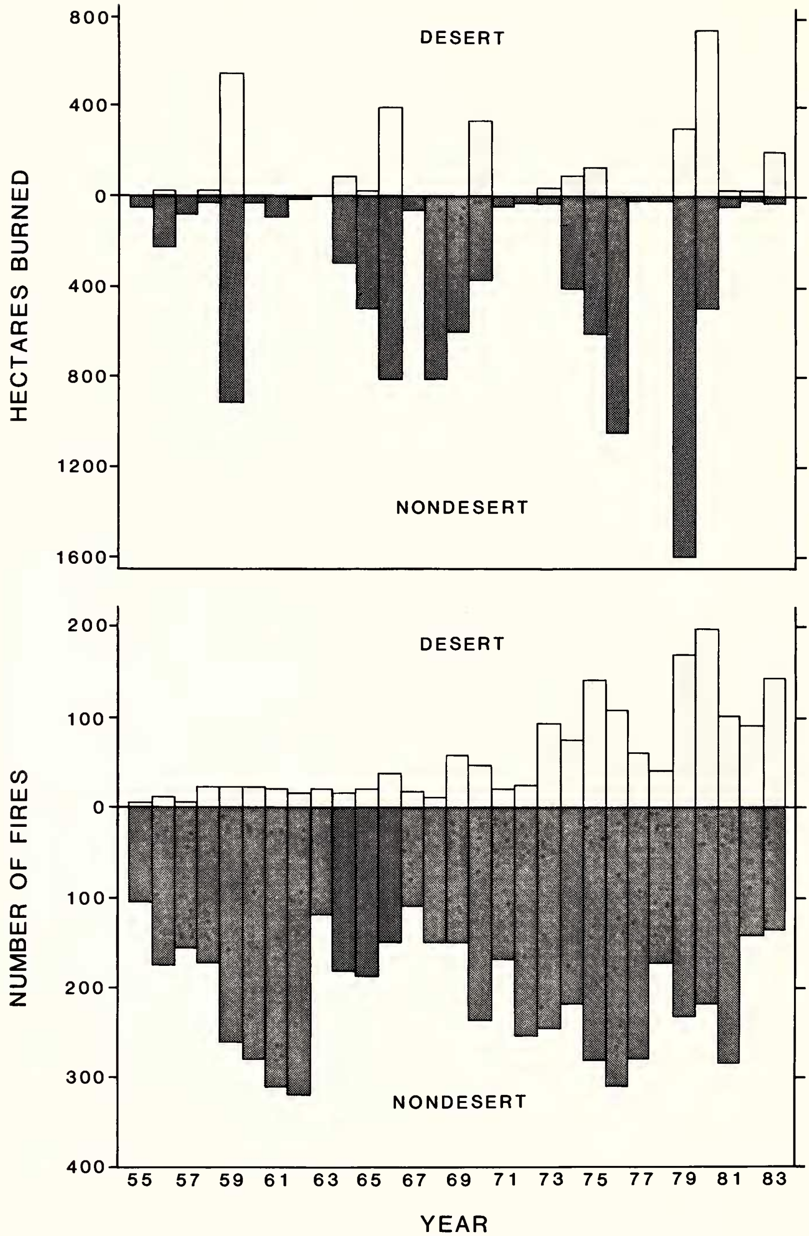

FIG. 1. Annual number of fires and hectares burned in the desert and nondesert portions of Tonto National Forest during the period 1955–1983.

TABLE 1. COMPARISON OF MEAN ANNUAL NUMBERS OF FIRES AND HECTARES BURNED PER KM² BETWEEN DESERT (total area = 3800 km²) AND NONDESERT (total area = 8140 km²) PORTIONS OF TONTO NATIONAL FOREST. Values are means ± s.e. (range in parentheses). * $p < 0.05$, ns $p > 0.05$.

n	Annual desert fires per km²	Annual nondesert fires per km²	*t*	Sign rank
Annual numbers of fires/km²				
29	0.015 ± 0.003 (0.001–0.053)	0.025 ± 0.002 (0.013–0.040)	3.92*	–
Annual hectares burned/km²				
29	0.352 ± 0.101 (0.000–1.939)	0.362 ± 0.092 (0.002–1.973)	–	28.5^{ns}

of individual fire report forms, computer summaries, and maps. This record includes location (Township, Range, and Section), date, size, and cause, and for fires ≥40 ha, maps (1:125,000) showing areas burned for all fires. The location information was used to classify desert and nondesert fires by plotting fire transferred from maps by Brown (1973) and Turner (1974). The vegetation maps are drawn at medium scales (1:500,000 and 1:250,000), and it is possible that small errors in boundary location resulted in misclassification of some fires. The record does not include size for fires that burned less than 0.11 ha. The size of these fires is recorded as 0.05 ha.

Vint and Rogers (in press) used regression analysis to test for annual trends (i.e., increases or decreases) in the number of fires and ha burned by nondesert fires. I repeated this analysis for nondesert fires (significance was tested using F for r^2, and t for slope), and I used correlation analysis to compare desert and nondesert fire occurrence. The assumption that desert fires are rare was tested by calculating and comparing ratios (t-test) of annual number of fires and ha burned per square kilometer (km²) in the desert and nondesert vegetation of TNF.

RESULTS AND DISCUSSION

Trends in nondesert fire occurrence were too small to measure using regression. For the desert vegetation Vint and Rogers (in press) reported positive trend (increase) in number of fires, but no trend in ha burned. The correlation of desert and nondesert fire occurrence was small: the Spearman rank-order correlation coefficient was 0.26 ($p > 0.05$) for annual number of fires and 0.47 ($p < 0.01$) for annual ha burned.

During the 29-yr period the total number of fires per km² in the desert (0.42/km²) was 58% of the nondesert (0.73/km²) fires. The mean number of fires per km² per year was smaller in the desert (Fig. 1, Table 1). Due to the increasing frequency of desert fires (Vint and Rogers in press), however, the difference declined over the period, and in five of the last nine years desert fires were more numerous than nondesert fires. The total number of ha burned per km^2 was about the same in TNF desert and nondesert vegetation (Table 1). Unlike number of fires, there was no trend in the difference in ha burned between desert and nondesert vegetation.

The similarity in area burned by desert and nondesert fires was not expected. A likely explanation is that fire suppression was less effective in limiting desert fires than nondesert fires because of the greater flammability of desert fuels. Regardless of fire suppression goals, actual achievements depend on several factors that include site accessibility and rate of fire spread. Accessibility is probably similar, but fire spread can be much faster typically in desert in comparison with nondesert vegetation because of fuel differences. Rate of spread depends on fuel compactness, fuel moisture content, and burning conditions (Rothermel 1983). Annual plants, principal fuels of desert fires, are well aerated. In June, when most desert fires occur, high temperature and low humidity lead to exceptionally low fuel moisture levels and highly favorable burning conditions. Lower temperatures, higher humidity, and more living plant material contribute to slower fire spread outside the desert, thus increasing opportunities for forces to limit fire size.

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